

PORTLAND HARBOR RI/FS
APPENDIX D
PRINCIPAL THREAT WASTE CAP MODELING
FEASIBILITY STUDY

DRAFT FINAL

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D1.0 PRINCIPAL THREAT WASTE CAP MODELING

Principal threat waste material has been identified at Portland Harbor. EPA guidance for PTW (USEPA 1991) states that, in some cases, source material ~~may~~ can be safely contained and that treatment for all waste will not be appropriate or necessary to ensure protection of human health and the environment, ~~or nor will it be~~ cost effective. Therefore, this appendix is evaluating whether or not PTW at the site can be reliably contained under specific assumptions.

Reliable containment is defined in this FS as having a contaminant concentration, measured in the sediment cap pore water just below the sediment cap-surface water interface that meets applicable regulatory levels for a period of 100 years. In this FS, the applicable regulatory levels are the lower of the Preliminary Remediation Goals (PRGs) established for surface or pore water under Remedial Action Objectives (RAO) 4 and 8, respectively, for a particular contaminant.

Modeled estimates of reliable containment are influenced by site characteristics (seepage velocity, starting sediment bed contaminant concentration), chemical characteristics (partitioning coefficients, diffusivities, degradation rates), and cap design (thickness of capping layers, amount of active material in cap). Five contaminants with various chemical characteristics, site seepage velocities spanning two orders of magnitude, and two potential active cap designs were modeled to determine the contaminant concentrations that cannot be reliably contained at the Site.

Model for Estimating Reliable Containment

Estimates of reliable containment were calculated using the Active Cap Layer Model v4.1 a Microsoft Excel-based capping model developed by Danny Reible of Texas Tech University (<https://www.depts.ttu.edu/ceweb/groups/reiblesgroup/downloads.html>). The model allows for the simulation of a contaminated sediment bed, an active cap layer, and a sand overlay ("conventional cap layer"). This general cap arrangement is the same as the representative process option cap presented in the FS. The model assumes linear adsorption of contaminants, which is often not a valid assumption for activated carbon. However, even given these limitations, the model is considered appropriate for developing screening level estimates of PTW concentrations that can be reliably contained.

Commented [TJF1]: Explain the consequence of this assumption. Does that mean the model tends to under predict or over predict for activated carbon?

Commented [TJF2]: By whom and on what basis?

Modeled Contaminants

Five contaminants were evaluated to determine whether PTW could be reliably contained. Because naphthalene and chlorobenzene represent two of the more mobile contaminants at Portland Harbor and are known to be present in conjunction with PTW materials, they were included in the model. The five modeled contaminants are:

- Benzo(a)pyrene
- Chlorobenzene
- DDT

- Naphthalene
- PCBs - Tetrachlorobiphenyl homolog group (sum of the tetrachlorobiphenyl congeners)

Model inputs are presented in **Table D-1**. K_{oc} values were calculated using the regression equation presented in the model as:

$$\text{Log } K_{oc} = 0.903 \times \text{Log } K_{ow} + 0.904$$

where:

K_{oc} = Organic carbon partitioning coefficient (unitless)
 K_{ow} = Octanol-water partitioning coefficient (unitless)

This relationship is not consistent between different classes of contaminants. However, the K_{oc} values presented in **Table D-1** were used for sediment pore-water partitioning calculations because these were performed independent of the model. Using chemical specific K_{oc} values provides a more accurate estimate of the equilibrium concentrations between phases than the generic relationship assumed in the model.

Contaminant Concentration Criteria for Determining Containment

The point of compliance for determining reliable containment is the contaminant pore water concentration just below the sediment cap-surface at 100 years. Acceptable concentrations at this compliance point are the lower of the applicable RAO 4 or 8 concentrations. These are presented in **Table D-2**.

General Modeling Approach Description

A two-phased approach was used to estimate concentrations of modeled contaminants ~~that cannot be reliably contained~~. Phase 1 evaluated the ability of a reactive cap to reliably contain these contaminants based upon reasonably conservative assumptions (for example, low seepage velocity, ~~no~~ contaminant degradation). For those contaminants where reliable containment could not be achieved under the Phase 1 scenario, Phase 2 was used. Phase 2 estimated the concentration of these contaminants ~~that could be contained~~ under an augmented reactive cap with conditions more conducive to containment.

Commented [TJF3]: This whole paragraph seems to be internally contradictory. Values presented in Table. Values calculated using regression model. Value in table are independent of the model.

Commented [TJF4]: According to the Phase 1 model inputs shown below, the model used no contaminant degradation. Why then is this a conservative assumption? I understand why low seepage velocity would be. No contaminant degradation seems to be non-conservative. Perhaps you need to better explain what you mean here.

Phase 1 PTW Modeling: Representative Process Option Cap

The RI database was used to determine the **maximum** reported concentration for each of the modeled contaminants. Preference was given to transition zone water (TZW, also identified as pore water) sample results, if those were not available for a particular contaminant, the highest reported sediment concentration for that contaminant was used. An equivalent porewater concentration was calculated assuming equilibrium partitioning and the K_{oc} values presented in **Table D-1** as follows:

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$$Conc_{porewater} = \frac{Conc_{sediment}}{f_{oc} \times K_{oc}}$$

where:

- $Conc_{porewater}$ = contaminant concentration in sediment ($\mu\text{g/kg}$)
- $Conc_{sediment}$ = concentration in sediment ($\mu\text{g/kg}$)
- f_{oc} = fraction of organic carbon (0.017)
- K_{oc} = Organic carbon partitioning coefficient

A fraction organic carbon (f_{oc}) of 0.017 was used, representing the average organic carbon content of surface sediment at the site. Porewater concentrations are presented in **Table D-3**

Specifics of the Phase 1 and 2 scenarios are provided below.

Phase 1 Model Inputs

A representative capping option was assumed, consisting of a two layer cap with of a 12-inch active layer of 0.12 pounds per square foot per centimeter ($\text{lb/ft}^2/\text{cm}$) activated carbon with an 18-inch sand overlay. This activated carbon loading rate equates to roughly **5 percent activated carbon** in the active cap layer, representing the percentage of carbon used in other Superfund caps (Berry's Creek in New Jersey and Bailey Creek, Fort Eustis in Virginia¹).

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A range of seepage velocities were evaluated (0.3 3, and 30 centimeters/day [cm/day]), representing the minimum, average, and maximum values measured at the site to better understand contaminant fate and transport under a range of conditions.

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The Phase 1 evaluation also assumed:

- Constant contaminant source in the sediment bed (inherent to the Active Cap Layer Model v 4.1 model design)
- **No contaminant degradation**

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¹

http://www.epa.gov/superfund/health/conmedia/sediment/pdfs/In_situ_AmendmentReportandAppendix_FinalApril2013.pdf; accessed March 26, 2015

- No sediment deposition on top of the cap
- No cap consolidation
- No underlying sediment consolidation

Model inputs regarding representative cap construction and site characteristics are presented in **Table D-4**.

Results

DDT, benzo(a)pyrene, and tetrachlorobiphenyl homologs are predicted to be reliably contained at a seepage velocity of 3 cm/day. As containment for these contaminants is expected at the approximate average seepage velocity and maximum observed sediment bed concentration, they were screened out from further consideration.

Chlorobenzene and naphthalene were estimated to not be reliably contained at a seepage velocity 3 cm/d. Therefore, a significantly augmented cap consisting of additional carbon for adsorption and a low permeability layer to retard seepage velocity was evaluated to determine concentrations of chlorobenzene and naphthalene that could be reliably contained.

Phase 2 PTW Modeling: Significantly Augmented Process Option Cap

Model Inputs

The active layer loading of the augmented cap was set to 0.48 lb/ft²/cm, and a low permeability layer limiting seepage velocity to 0.3 cm/day was assumed. Degradation rates of 0.59/year for chlorobenzene² and 3.04/year for naphthalene³ were assumed, representing the upper range of reported values. Degradation was simulated in the augmented cap scenarios as sufficient residence time in the cap was assumed due to the presence of the low permeability. All other model inputs remained consistent with those of Phase 1.

Results

Maximum containable sediment concentrations of 320 µg/kg and 140,000 µg/kg for chlorobenzene and naphthalene, respectively, were back-calculated using the model (**Table D-2**). Concentration profile plots are shown on **Figures D-1 and D-2**.

² In a comprehensive review of studies evaluating anaerobic biodegradation of chlorobenzene in river sediment, Malcolm et al., (2004) report half-lives ranging from 17 to 433 days. These studies primarily consisted of assays of extracted river sediment slurries incubated in a laboratory setting.

³ ATSDR 2006, reported that sediments affected by differing contaminants can lead to different degradation rates. Variation in site conditions and naphthalene speciation would result in a half-life biodegradation rate in sediments for naphthalene from 2 to 83.3 days.

Commented [TJF5]: We seem to have jumped to the end here without specifically explaining the results of the Phase 2 model runs. Reading between the lines one can infer that at the highest porewater concentrations containment was still not achieved? The report needs to be more explicit.

Commented [TJF6]: 1. OK, now how about circling back to the non-linear AC adsorption assumption. In which direction would that move the needle if it were incorporated into the model? 2. What is the model most sensitive to? Seepage rate or AC concentration? Are there reasonable scenarios to use a less permeable cap to achieve success or how much does the AC need to be increased?

Commented [TJF7]: Given that at the outset you characterize this as a screening level model ("...appropriate for developing screening level estimates..."), before anyone makes critical remedy and design decisions should more definitive/refined modeling be recommended? The FS appears to use the results of this model as gospel, ignoring the fact that it is a screening level model.

Principal Threat Waste that can be reliably contained

The following table summarizes the results of the Phase 1 and 2 modeling efforts.

| Contaminant | Principal Threat Waste That Can be Reliably Contained |
|------------------------------|--|
| Benzo[a]pyrene | PTW that can be reliably contained; modeling efforts estimate reliable containment |
| Chlorobenzene | <320 µg/kg |
| DDT | PTW that can be reliably contained; modeling efforts estimate reliable containment |
| Naphthalene | <140,000 µg/kg |
| Tetrachlorobiphenyl Homologs | PTW that can be reliably contained; modeling efforts estimate reliable containment |

D2.0 REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 2006. Toxic Profile for Naphthalene, 1-Methylnaphthalene, and 2-Methylnaphthalene.
<http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=240&tid=43>

Malcolm, H., Howe, P., Dodson, S. 2004. *Chlorobenzenes other than hexachlorobenzene: Environmental aspects*. Concise International Chemical Assessment Document 60. World Health Organization, Geneva.